THE MOST COMMONLY ASKED QUESTIONS ABOUT BUILDING ENCLOSURES

Many JBL users build their own loudspeaker enclosures. Their audio skills range widely from novice to expert. From the thousands of letters and calls we have received addressing the subject of loudspeaker enclosure construction, we have determined the most common questions and present the following Questions and Answers. The particular questions listed attempt to answer as many questions as we feel are necessary to provide enough information to build an enclosure which will allow your JBL loudspeaker to operate to its potential. The questions selected here concentrate on vented "bass reflex" enclosures, since low frequency horns are fairly complex, and many good tested designs exist. Also, it is often more econonomical to buy a bass horn enclosure than to build one. Vented box enclosures are by far the most popular enclosure type. Vented boxes are finding increasing use by touring sound companies, displacing existing horn enclosure designs because of the greater low frequency power output and extended low frequency capability they offer when used in arrays. In addition to their simple design requirements, vented loudspeaker enclosures offer flexibility of design in shape, weight and component complement, and usually produce the best results obtainable from modern loudspeaker drivers at the lowest cost.

[1]
Q: What makes a good vented enclosure?

A: Basically, an enclosure serves to partition the front and rear of the driver's cone, preventing the opposing air pressure changes produced by cone motion from cancelling, and allowing the radiation of sound from the front of the driver only. In addition, vented enclosures allow the compressibility of the air inside the enclosure to work as a more active part of the "system" consisting of driver and enclosure. Beyond these two basic functions, a low frequency loudspeaker enclosure should do absolutely nothing, that is, it should add no effects of its own--no vibration, no tonality, no motion--nothing to interfere with or absorb acoustic energy produced by the driver.

[2]
Q: Is it possible to get low, punchy bass from a small enclosure?

A: Yes, if the driver in the enclosure is designed for low bass operation in a small enclosure. Unfortunately, it's usually a small driver that can work properly in a small enclosure, and that dictates that lower sound levels will result from the small amount of air such a small driver can move. Larger boxes (with larger bass drivers) produce more bass, smaller boxes produce less bass. It's a fact of life, like the fact that it takes a bass viol, a tuba, longer piano strings, or very large organ pipes to produce bass energy in the air. Low bass requires that more air move, and bigger boxes contain more air that can be put to work making low bass.

[3]
Q: Can I get more bass from my enclosure by installing a bigger driver?

A: A given enclosure will not automatically produce more bass when a larger driver is installed, in fact the opposite is often the result.

[4]
Q: What about putting two drivers in the enclosure to increase bass?

A: Placing two bass drivers in an enclosure designed for one will usually produce less bass and more midrange output, and will upset the operation of the driver-enclosure system because each driver will behave as though it is installed in an enclosure which has only half the internal volume of the original enclosure (with one driver).

[5]
Q: What should I do to use two drivers (for more bass)?

A: There are two alternative possibilities. When using two identical drivers, you can build an enclosure with twice the internal volume of the original enclosure that contained one driver, or you can duplicate the original enclosure and stack the two. As the latter alternative suggests, when building the double enclosure, it's necessary to treat the enclosure as if it were two enclosures--you must double the porting used on the single smaller enclosure--although it is not necessary to divide the volume of the double enclosure unless two different driver models (e.g. E130 and E155) are used and their interaction would be undesirable. A usable example of this might be a 227 liter (8 cubic foot) enclosure divided into two chambers so that the E130 occupies 57 liters (2 cubic feet) and the E155 occupies 170 liters (6 cubic feet). In this case, the ports tuning either chamber to the same desired frequency will be quite different.

[6]
Q: What does port or enclosure "tuning" mean?

A: In exactly the same way the resonant note from a bottle can be raised and lowered by adding or pouring out liquid to change the bottle's air volume, enclosure tuning is affected by the ratio of air volumes in the port (the bottleneck) with its attendant flow resistance, and the enclosure interior volume. Tuning of loudspeaker enclosures is a result of manipulating the differences in effective air mass between the enclosure interior and the air in the port. The bottle-like nature of a vented enclosure is known as a "Helmholtz resonator." The ports or ducts in a vented enclosure work only over a narrow band of frequencies near the chosen tuned frequency, producing the same effect noted when blowing across a bottleneck--a single distinct pitch.

[7]
Q: Is it always necessary to use a port for good bass?

A: JBL uses vented enclosure designs because they are superior to sealed enclosure designs in several important ways--as long as it is possible to tightly control the loudspeaker driver parameters in manufacturing as JBL does. Vented designs produce lower distortion at the lowest operating frequencies, afford the driver protection against mechanically destructive large cone excursion, and better enable the driver to absorb and utilize its full power rating from an amplifier when operating at low frequencies. It is important to keep in mind that porting and tuning an enclosure provides air loading for the bass driver down to frequencies just below the Helmholtz frequency, but does not provide any loading for the driver at frequencies below that, such as subsonic turntable rumble, record warp or microphone wind pickup. If you intend to operate a sound system at high power levels, we highly recommend an electronic high-pass filter to eliminate subsonic input to the power amplifier(s). This will substantially increase the available useful power from the amplifier which will then only operate in the audible frequency range. Such a filter is the UREI model 501 Sub Sonic Processor, or the built-in sub-sonic switches of the JBL Electronic Frequency Dividing Network model 5234A.

[8]
Q: Where should I locate the port(s) with respect to the woofer?

A: Bass reflex enclosures are usually designed to tune from about 100 hertz and down. The length of sound waves at these low frequencies is over 11 feet, so port placement is not critical. Ports may be located anywhere on the baffle with no change in bass performance; some designs even locate ports on the back of the enclosure which works well as long as the enclosure is not close to a wall (a couple of port diameters away) and there is an unobstructed air path between the woofer and the port. Overall, it's safest to locate the port somewhere on the baffle with the woofer(s) far enough away from side walls to avoid interaction between port and enclosure wall or the fiberglass insulation on the wall.

[9]
Q: What should the ducts be made of? Is round better than rectangular?

A: Port ducts may be made of anything rigid, such as paper cardboard with about a 1.5 mm (1/16") or larger wall thickness. They can be any shape, square or rectangular (such that port area remains constant) and made of wood or other suitable material. It is not necessary to use PVC pipe for port tubing, particularly when most carpet stores throw away large amounts of heavy carboard tubing of between 3 and 4-1/2 inches inside diameter.

[10]
Q: What is the relationship of duct length to port area?

A: When port area is increased, independently of other factors, enclosure tuning is raised. If duct length is increased, independently of other factors, enclosure tuning is lowered. To keep the same tuning (Helmholtz frequency) you will need to increase duct length as you increase port area.

[11]
Q: How big should the port be?

A: The bigger, the better. Any port causes some resistance to air movement, and so introduces unavoidable losses in output to the system as a whole. The ratios of port area and length and enclosure volume determine the Helmholtz frequency tuning. Mechanical reactance elements, stiffness and air mass, control the effective air mass ratios. At very low operating levels, where air in the port does not move very fast, a small short port will behave the same as a large longer port as far as enclosure tuning is concerned. At high power levels however, the restricted air flow of the smaller port will produce output level losses, some de-tuning and at high enough levels a small port will cause the enclosure to behave like a sealed enclosure with little or no contribution from the port. To minimize resistive losses, the largest practical port should be used. Computer listings of port choices calculated to limit air velocity inside the port duct will list duct sizes which are normally impractical. A 380 mm (15 in) diameter port is not an unreasonable choice for a 380 mm bass driver, however the necessary length would dictate that such a port might itself have a volume of many cubic feet, sometimes equal to or larger than the original enclosure. A good rule of thumb would be to avoid ports whose circular area is smaller than at least 1/3 the diameter of the driver such as a 127 mm (5 in) diameter port for a 380 mm (15 in) driver. This will usually provide sufficient port area so that the port will not "whistle" when the system is operated at high power levels near the helmholtz frequency--a sure indication of severe system losses and potential power compression and low-frequency output limiting.

[12]
Q: Can I use several smaller ports instead of one big one?

A: Yes, however there is a phenomenon associated with air resistance resulting from air drag on the internal surfaces of port ducts and turbulence at the ends of the ports that requires a duct length correction when several ports are used. For example, when using four 100 mm (4 in) tubes instead of one 200 mm (8 in) tube (which has the same port area but one-quarter the internal surface area), the length needed will be slightly less than that needed for the single 200 mm tube, perhaps 5% to 10% less, depending on overall enclosure volume. These effects exhibited by port ducts is exaggerated by proximity of the duct to enclosure interior surfaces or any other type of boundary that may cause air turbulence near the end of the duct, therefore it's important to keep duct ends away from the rear of the cabinet or other obstructions by an amount at least equivalent to or larger than the dimension across the port. If you are using a rectangular port that has as one of its sides, an enclosure wall, you might have to use some correction.

[13]
Q: Is there a simple mathematical way of designing proper enclosures?

A: Yes, a JBL scientist, D.B. Keele Jr., simplified the work of A. Neville Thiele and Dr. Richard Small so that anyone with a pocket calculator and a ruler or straight edge can design the right enclosure volume and choose the right port or duct for a given loudspeaker driver. JBL offers, at no cost, a four-page "kit" containing detailed step by step instructions, written specifically for non-mathematicians, showing how to use published Thiele-Small driver parameters in enclosure design. Examples are shown with their results graphically represented. An enclosure design flow chart and enclosure venting nomograph are included.

[14]
Q: Should the enclosure's baffle be removable?

A: This is a question of mechanical strength and rigidity. All enclosures, particularly those intended for rough portable use, should be constructed with all sides permanently fixed by glue and screws, and sealed air-tight by virtue of well cut and glued joints. It is preferable to mount loudspeakers from the front of the baffle board to eliminate the possiblity of reflections from the inside of the loudspeaker mounting hole, thus it becomes unnecessary to provide for removing the baffle. Woofer openings are usually large enough to reach through in order to work inside the box, for example, to install other components.

[15]
Q: Is there a preferred shape for loudspeaker enclosures?

A: There are a number of shapes that improve performance and some that cause distinct degradation in performance. For single, full-range drivers (e.g. JBL's LE8T) a sphere is the ideal shape for an enclosure because the curved surfaces avoid the diffraction effects of cabinet edges, which bend sound waves in a manner dependent on frequency. For multi-way loudspeaker systems, spheres are usually impractical because of the large size needed and because of the precise orientation required for optimal listening. Conventional enclosures work best mounted flush into a wall where diffraction is controlled by virtue of the wall surface, and for free-standing enclosures, tilting, angled and curving surfaces may be employed to help reduce or control edge diffraction. The overall shape of the enclosure is relatively unimportant except where the shape makes it difficult to build a rigid enclosure. It is best to avoid enclosure dimensions that are multiples of each other, such as 1 X 2 X 4 ratios, and strive to use dimensions that have somewhat unrelated ratios such as 1 X 1.23 X 1.41.

[16]
Q: What is the best material to use for building enclosures?

A: For home and permanent installation use, high density particle wood is the most cost-effective material for general enclosure construction. The best wood to use for portable enclosure construction is 14 to 20 ply per inch Finland birch type. Birch plywood is very expensive however, and a carefully braced enclosure made of high grade void-free fir plywood can do the job just as well in most cases. The thicker you can make the cabinet walls, the better the results will be because of reduced wall vibration and resonance, but the tradeoff is cost and weight. Enclosure walls should be cut so that edges form an air-tight seal when glued together. Cleats and caulking can also be used if needed to insure a good fit and tight air seal.

[17]
Q: Is bracing necessary? How much should be used?

A: Bracing should be added to the enclosure interior to minimize enclosure wall vibration. Enclosure walls simply cannot be stiff enough since wall vibration indicates that energy is being wasted to move enclosure panels rather than moving air. 25 X 76 mm (1 X 3 in) pine bracing fixed on edge with glue and screws to the enclosure walls will help provide the minimum necessary stiffening without affecting the internal volume significantly. If you are building large subwoofer enclosures, bracing with two-by-fours works better, though you should take the bracing volume into account since a 3 m (10-foot) length takes up 12.9 liters (0.36 cubic foot) of enclosure volume.

[18]
Q: How should I mount drivers on the baffle?

A: Mount drivers on the front of the baffle whenever possible to avoid the reflections from inside the mounting hole. Heavy drivers should normally be front-mounted using Tee-nuts and machine screws or JBL's MA15 clamps. If Tee-nuts are used, apply a bit of Bostic or Pliobond type rubber glue to the inside of the nut flange to help avoid losing the Tee-nut inside the enclosure when installing the driver. Baffle board construction is much easier if all baffle parts are assembled prior to final box assembly.

[19]
Q: Do I need fiberglass inside the enclosure?

A: JBL uses a 25 mm (1 in) padding of 1/2-pound density fiberglass stapled to the enclosure interior on all surfaces except the baffle. You should use 100 mm (4 in) thick dacron or 25 mm (1 in) fiberglass on at least three of the surfaces of parallel interior walls. Keep sound absorbing materials away from the port(s) as the air velocity inside the port can be sufficient to tear off bits of the material and squirt them out of the enclosure. It is not necessary to cover the inside of the baffle, but doing so will rarely degrade system performance. The enclosure exterior may be covered with your choice of any suitable finish or decoration; this will not affect bass performance and in some cases (as with Formica) may help stiffen the enclosure walls.

[20]
Q: Does Fiberglass significantly affect enclosure tuning?

A: No, not unless the enclosure is stuffed full of fiberglass, in which case the apparent volume of the enclosure increases by 12% to 20% as seen from the point of view of the bass driver. Stuffing the enclosure full with fiberglass is not recommended because it introduces system losses, is expensive and interferes with port operation. The exception to this would be a sealed "air suspension" type system enclosure where more virtual volume is needed and actual volume is not available, and/or where box dimensions which are multiples of each other can't be avoided and the fiberglass stuffing will help absorb the internal sound reflections.

[21]
Q: What is needed to mount a midrange on the baffle with the woofer?

A: For cone-type midrange drivers, a sealed sub-chamber should be used to prevent interaction with the enclosure's bass driver. JBL drivers suitable for sealed-chamber midrange use require only 10 to 40 liters (.3 to 1.0 cubic foot) of chamber volume to operate at typical midrange frequencies, above 200 hertz. Subchambers should be constructed solidly and liberally lined with fiberglass. As in the case of enclosure shapes, avoiding multiples of dimensions, subchambers should be built so as to avoid square and cube shapes in favor of non-related numerical ratios.

[22]
Q: Is there any special procedure for mounting a horn in an enclosure?

A: Use of a horn/compression driver does not require any subchamber since these devices form their own air-tight seal. JBL horns such as the 2344, 2370, MI-291 and 2380 horn family also seal their own cutout opening in the enclosure when properly mounted on the baffle. Better compression drivers are quite heavy, so a brace should be provided to cradle the driver to prevent driver movement during shipping. In combination with the length of a horn as a lever, driver mass can cause the assembly to tear off the baffle or break the horn if the enclosure is handled roughly or dropped. Driver mass can also tear off the horn throat if cabinets are dropped on their backs.

CONVERSION CONSTANTS and USEFUL DATA

LITERS	FEET^3	INCHES^3	METERS^3
1.00 =	.03531 =	61.0 =	.001
28.32 =	1.00 =	1,728 =	.02832
1000.00 =	35.31 =	61,016 =	1.00

MILLIMETERS	INCHES	METERS
1.00 =	.039 =	.001
25.40 =	1.000 =	.0254
1000.00 =	39.370 =	1.000

TO FIND SOUND WAVE LENGTH: divide velocity of sound by frequency (Hz)
(SOUND VELOCITY = 344 m/s, 1130 ft/s or 13,560 in/s)

AREA OF CIRCLE = 3.14 x (radius squared)   Note: radius = 1/2 diameter

TO FIND THE DIAMETER OF A CIRCLE WITH EQUIVALENT AREA:
2 x square-root of (area divided by 3.14)
example: area of 9" tube = area of 8" square duct calculated:
(area) 64/3.14=20.37, square root = 4.51 x 2 = 9.03 (diameter)

VOLUME OF CYLINDRICAL DUCT = circular area x length

VOLUME DISPLACED BY JBL LOUDSPEAKERS: 8" = .05 cu ft, 10" = .1 cu ft, 12" = .15 cu ft, 15" = .2 cu ft, 18" = .3 cu ft.

JBL LOUDSPEAKER MOUNTING HOLE AND BOLT CIRCLE DIMENSIONS:
mounting holes:
8" = 7-1/16"   10" = 9"   12" = 11-1/16"   15" = 13-31/32"
18" = 16-13/16"

bolt circles:
8" = 7-5/8"   10" = 9-3/4"   12" = 11-9/16"   15" = 14-9/16"
18" = 17-3/8"

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